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"FUNGI FUTURES: SUSTAINABLE MUSHROOM CULTIVATION FOR A GREENER TOMORROW"

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ABSTRACT

This study investigates the use of rubber pellets as an alternative substrate for cultivating *Hypsizygus ulmarius* (elm oyster mushroom), emphasizing their potential to enhance sustainable agriculture. Compared to traditional substrates like paddy straw and sawdust, rubber pellets improve moisture retention, aeration, and durability while reducing contamination risks, resulting in a total yield of 36,000 g and enabling continuous production. The findings support the mushroom's recognized bioactive properties, such as antioxidant activity and elevated vitamin D_2 content, while also promoting waste recycling and reducing the environmental footprint of mushroom farming. Rubber pellets emerge as a cost-effective, eco-friendly option for large-scale cultivation, contributing to food security and sustainable substrate management. Future research should focus on optimizing enzymatic activity, enhancing bioactive compound extraction, and evaluating the economic feasibility of rubber-based substrates in commercial production.

KEYWORDS: *Hypsizygus Ulmarius*, Mushroom Cultivation, Rubber Pellets, Sustainable Agriculture, Bioactive Compounds, Substrate Optimization, Waste Recycling, Food Security

INTRODUCTION

Mushroom cultivation has emerged as a vital component of sustainable agriculture, offering nutritional, medicinal, economic, and ecological benefits. Among edible fungi, oyster mushrooms—particularly *Hypsizygus ulmarius*—are favored for their adaptability, rapid growth, and ability to thrive on a wide range of organic substrates. Their global demand has surged due to their high protein, fiber, vitamin, and antioxidant content, establishing mushrooms as a valuable functional food (Suman & Sharma, 2007). Often referred to as "white vegetables" or "boneless vegetarian meat," mushrooms contain 20–35% protein (dry weight), surpassing many plant-based foods in nutritional value. They also help reduce environmental pollution by converting lignocellulosic waste into protein-rich biomass, while their cultivation byproducts serve as manure, animal feed, and soil conditioners (Mattila *et al.*, 2001).

The global production and consumption of edible fungi continue to increase, especially in regions such as Asia, Europe, and North America. China currently dominates the global mushroom market, contributing nearly 75% of total production, driven by technological advancements in yield efficiency and quality (Royse *et al.*, 2017). Innovative approaches in mushroom farming—such as biofortification, improved substrate use, and vitamin D enrichment—have enhanced both the nutritional and commercial value of mushrooms. Moreover, mushroom farming contributes to climate change mitigation by utilizing agricultural residues that would otherwise emit greenhouse gases. Their ability to produce vitamin D when exposed to UV light makes them especially valuable in regions with limited sun exposure.

Traditionally, substrates like paddy straw and sawdust have been used for mushroom cultivation, but they present challenges such as inconsistent quality, contamination risk, and limited sustainability. Recent research has explored alternative substrates such as rubber sawdust and processed rubber pellets, which are derived from rubber wood and recycled rubber materials. These substrates offer advantages including better moisture retention, structural stability, and contamination resistance. Studies have shown that rubber-based materials support the growth of high-value mushroom species and may enhance enzymatic activity due to their lignin-rich composition (Kumla *et al.*, 2020). This novel approach not only supports sustainable waste management but also paves the way for eco-friendly, large-scale mushroom production with improved yield and bioactive compound development.

MATERIALS AND METHODS

Materials:

Hypsizygus ulmarius was cultivated using rubber pellets (1 kg/bag) enriched with calcium carbonate (15 g) and hydrated with boiled water (1.5 L). Certified mushroom spawn (150 g/bag) was sourced from Oushadi. Polypropylene bags, surgical tools, gloves, and masks were used to maintain sterility. Cultivation was conducted in three dedicated rooms: incubation (dark, 22–28°C), fruiting (light, 22–25°C, 85–90% humidity), and composting. Environmental control tools included thermometers, spray bottles, exhaust fans, coolers, LED lights, and ropes for hanging bags.

Methods:

Prepared bags were hydrated, mixed with spawn, and sealed with breathable slits. Incubation lasted 15–25 days in darkness until full mycelial colonization. Fruiting was induced under light and high humidity, and mushrooms were harvested 10–15

days post-pinning. Six bags were processed daily, resulting in a cumulative yield of 36 kg. Spent bags were composted post-harvest. Sterile techniques and controlled conditions ensured optimal growth and minimal contamination.

RESULT AND DISCUSSION

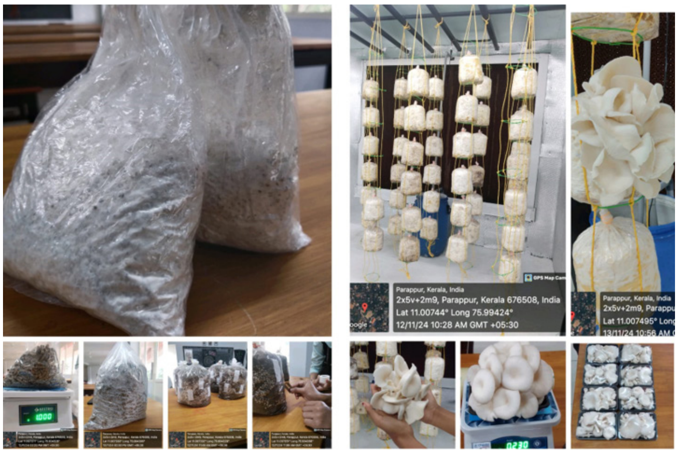
In this study, *Hypsizygus ulmarius* was cultivated using rubber pellets as an alternative substrate to traditional paddy straw. A total of 36,000 g of mushrooms was harvested by maintaining a daily cycle of six bags, demonstrating the reliability and productivity of this method. Rubber pellets provided a more consistent and durable substrate, allowing for prolonged nutrient availability and better structural integrity throughout the cultivation process (Jayaraman *et al.*, 2024). This uniformity contributed to stable mycelial growth and reduced substrate breakdown compared to paddy straw, which often varies in quality and decomposes rapidly.

Rubber pellets also offered superior moisture retention and aeration, creating an optimal microenvironment for mycelial colonization and fruiting. These physical properties minimized the need for constant misting and helped avoid anaerobic conditions that can lead to contamination. The reduced risk of microbial infections is especially beneficial for *H. ulmarius*, known to be sensitive to competing organisms. This observation aligns with previous studies highlighting the sterility advantage of non-organic substrates (Beetz & Kustudia, 2004). Furthermore, the adoption of hanging ropes instead of racks improved vertical space usage, air circulation, and hygiene, making it a cost-effective and practical system for both small-scale and commercial growers.

In addition to yield benefits, the environmental and economic advantages of rubber pellets were evident. Their use supports waste recycling and reduces the environmental impact caused by paddy straw burning (Alam & Raza, 2001). Though initial costs may be higher, the reusability and durability of rubber pellets ensure long-term savings and substrate efficiency. These findings confirm that substrate composition directly influences mushroom yield and biological efficiency (Chang & Miles, 1992; Wood & Smith, 1987), positioning rubber pellets as a sustainable, high-performing option for mushroom cultivation.

Week	Start Date	End Date	Collection (kg)	Total Collected (kg)
Week 1	Nov 25, 2024	Dec 1, 2024	2 kg	2kg
Week 2	Dec 2, 2024	Dec 8, 2024	6kg	8 kg
Week 3	Dec 9, 2024	Dec 15, 2024	8 kg	16 kg
Week 4	Dec 16, 2024	Dec 22, 2024	5 kg	21 kg
Week 5	Dec 23, 2024	Dec 29, 2024	6 kg	27 kg
Week 6	Dec 30, 2024	Jan 5, 2025	4 kg	31 kg
Week 7	Jan 6, 2025	Jan 12, 2025	5 kg	36 kg (Final)

Table 1 : Mushroom Cultivation Collection Schedule (Nov 2024 – Jan 2025)



Photos Showing Various Stages of Mushroom Cultivation

SUMMARY AND CONCLUSION

This study highlights the successful use of rubber pellets as a sustainable and efficient substrate for cultivating *Hypsizygus ulmarius*. Compared to traditional paddy straw, rubber pellets demonstrated superior durability, moisture retention, and resistance to contamination—factors crucial for consistent mushroom growth. With a structured daily routine of filling six bags, a total yield of 36 kg was achieved, showcasing the method's scalability and efficiency. The enhanced biological efficiency observed aligns with prior research emphasizing the importance of substrate composition in optimizing yield (Jayaraman *et al.*, 2024). Furthermore, the cultivation method promotes environmental sustainability by utilizing recycled rubber materials, thus reducing pollution associated with paddy straw disposal (Masaphy *et al.*, 2023).

In conclusion, rubber pellets offer a viable and eco-friendly alternative for commercial mushroom cultivation. Their reusability, structural stability, and consistent nutrient availability make them a cost-effective solution for long-term production. Additionally, *Hypsizygus ulmarius* continues to attract interest due to its bioactive properties, including antioxidant and immunomodulatory effects (Bhatia *et al.*, 2024; Aditya *et al.*, 2025). Integrating rubber-based substrates into mainstream cultivation practices not only enhances productivity but also supports sustainable agriculture and the circular economy. Future research should explore the broader applicability of this method across different mushroom species and evaluate its economic impact on commercial-scale operations.

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